Evaluation of CMAQ prediction of carbon monoxide vertical profiles against SENEX

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Purpose

- To evaluate CMAQ CO in the upper and lower troposphere in the SE US
- To determine whether biomass burning may have influenced the accuracy predictions even in areas dominated by anthropogenic emissions
- Importance of CO
  - Used to determine emissions of other trace gases through ratios of gas concentrations; combustion tracer
  - Ozone precursor
  - Criteria pollutant

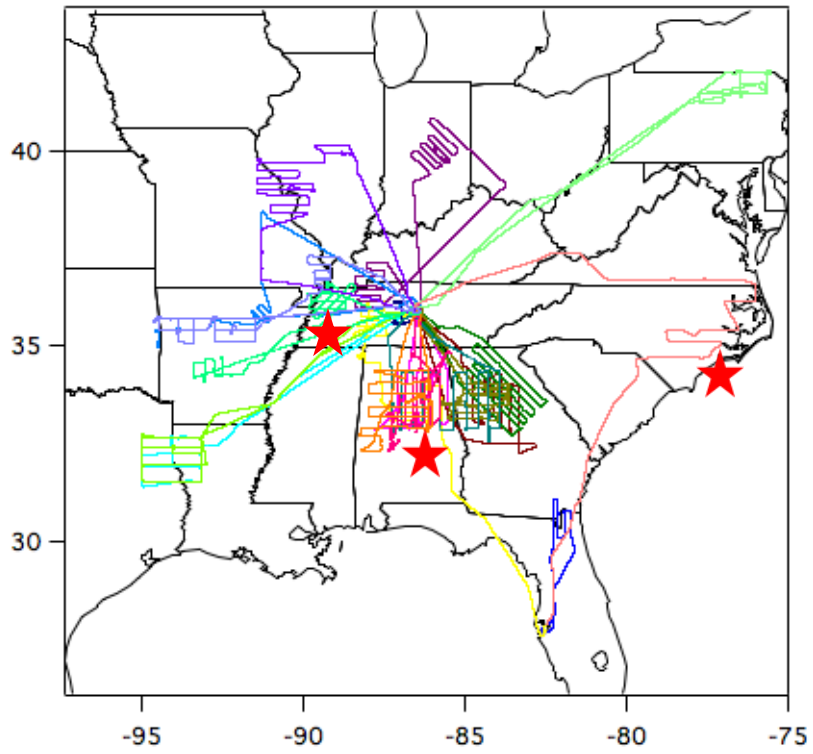
Methods

- Determination of biomass burning influence on different flights and different altitudes through acetonitrile (C2H3N) concentrations and C2H3N-CO correlations
- Production of CMAQ output using version 4.7.1 with the following inputs:
  - Anthropogenic emissions: NEI 05 with projections to 2013
  - Biogenic emissions: BEIS 3.13
  - Wild fire: HMS and BLUE SYS
- Matching of CMAQ output to SENEX observations by time, altitude, and horizontal coordinates
- Statistical analysis

Possible Causes of High Acetonitrile

- Biomass burning (Holzinger et al. 1999)
  - Plume in lower troposphere indicates that the fire would probably have occurred nearby
  - Plume in upper troposphere indicates transport
- Fireworks (Drewnick et al. 2006)
  - No evidence of high acetonitrile or a high acetonitrile-carbon monoxide correlation in a nearby sampled area from the SENEX 7/05 flight
  - But possibly early Independence Day festivities influenced 7/03 data

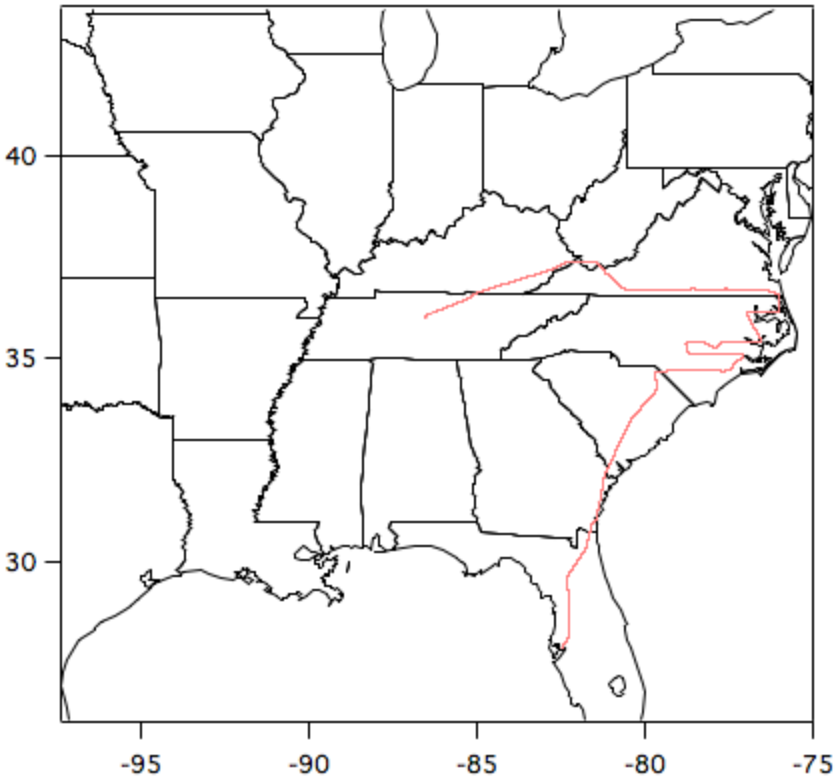
SENEX Campaign Region



- A series of 19 aircraft flights in the SE US in 2013
- Focused on anthropogenic emissions
- CO measured using UV resonance fluorescence
- VOCs measured using chemical ionization mass spectrometer
- I will focus on 3 case studies

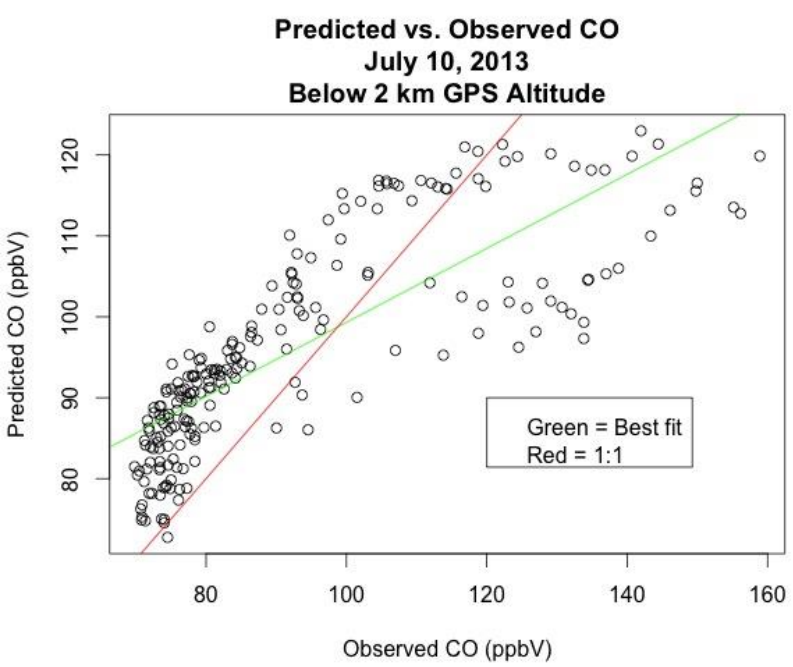
Image from:
http://www.esrl.noaa.gov/csd/groups/csd7/measurements/2013senex/P3/flighttrack/

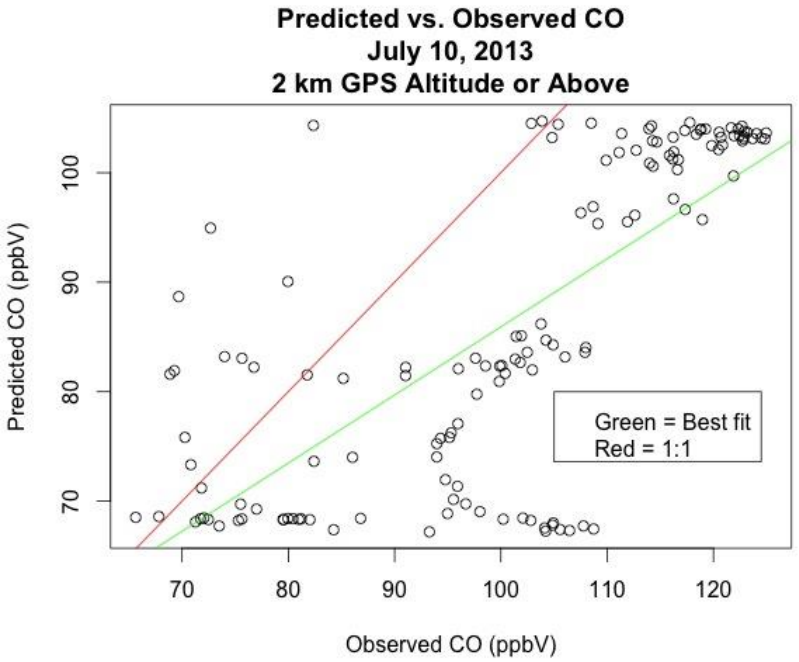
7/10/2013 SENEX Flight Path



- Passed over hog CAFOs (concentrated animal feeding operations), coal mines

CO Evaluation 7/10



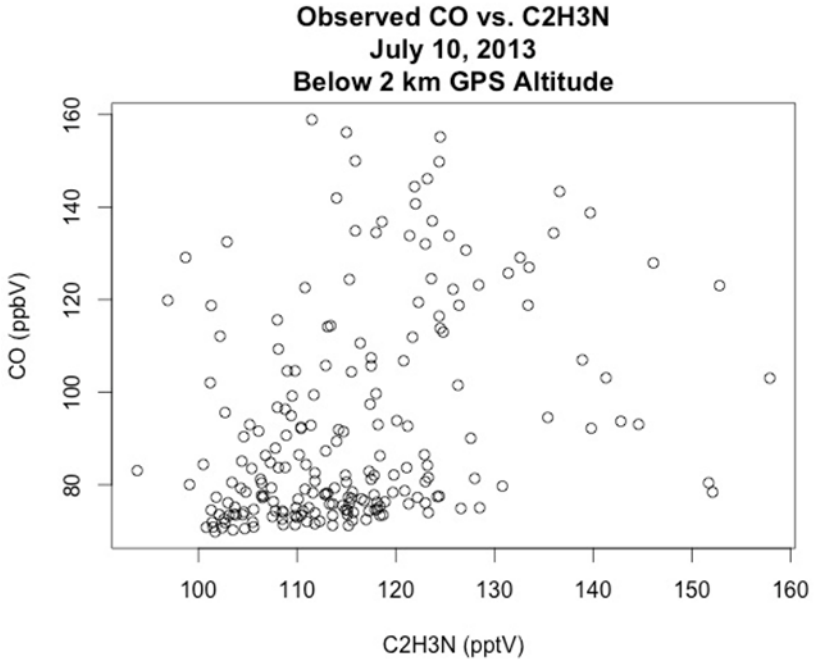


Mean bias = 3.54 ppbV
Mean error = 12.23 ppbV
N = 217

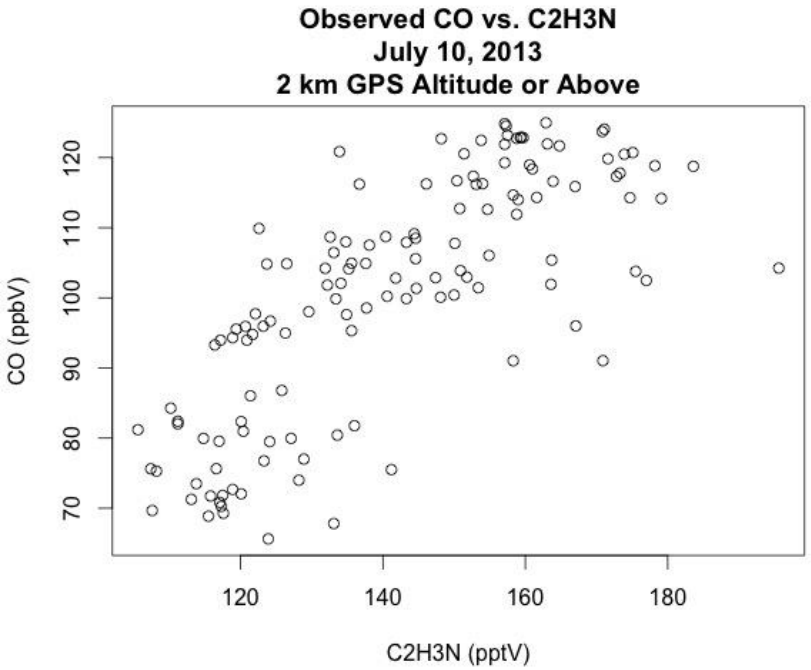
Mean bias = -14.61 ppbV
Mean error = 16.26 ppbV
N = 137

In both the lower and upper troposphere, CMAQ tends to underpredict high CO concentrations; in the upper troposphere, there was an overall underprediction.

CO-C2H3N Correlation 7/10



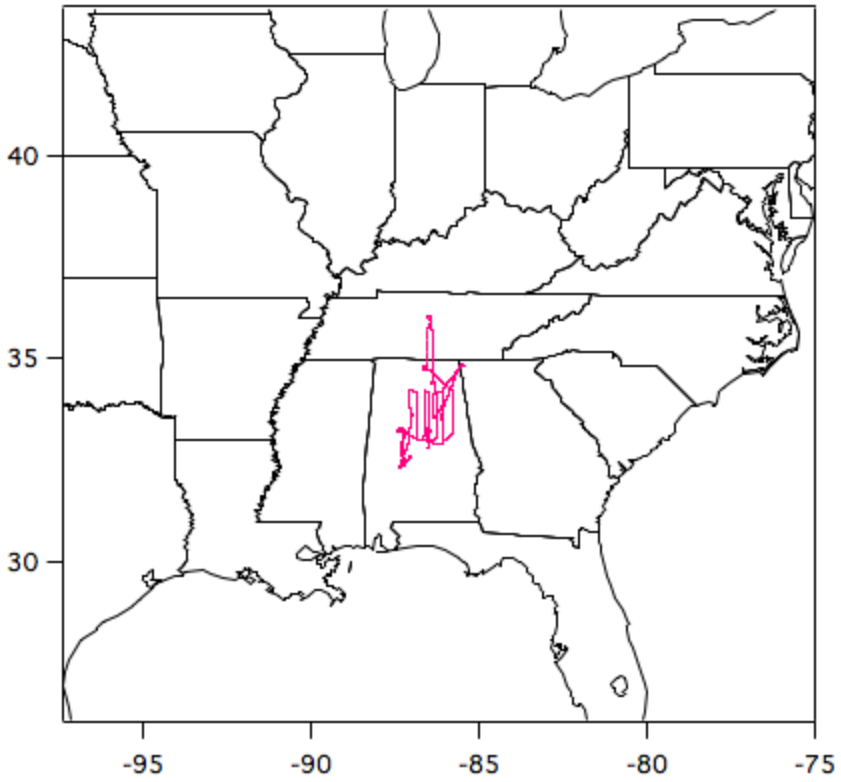
Correlation = 0.352



Correlation = 0.758

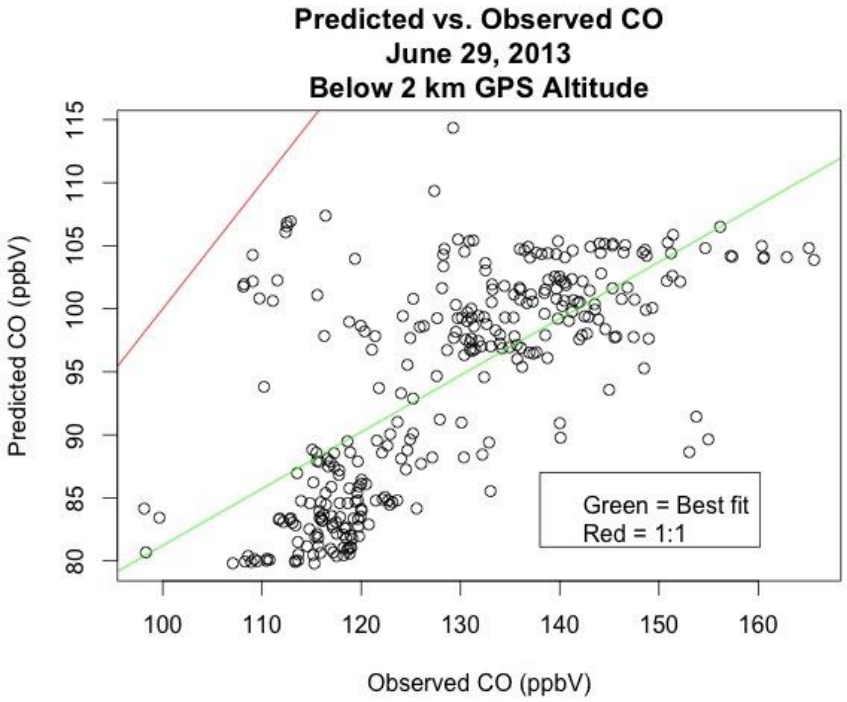
The correlation is fairly high in the upper troposphere, but there is no obvious plume.

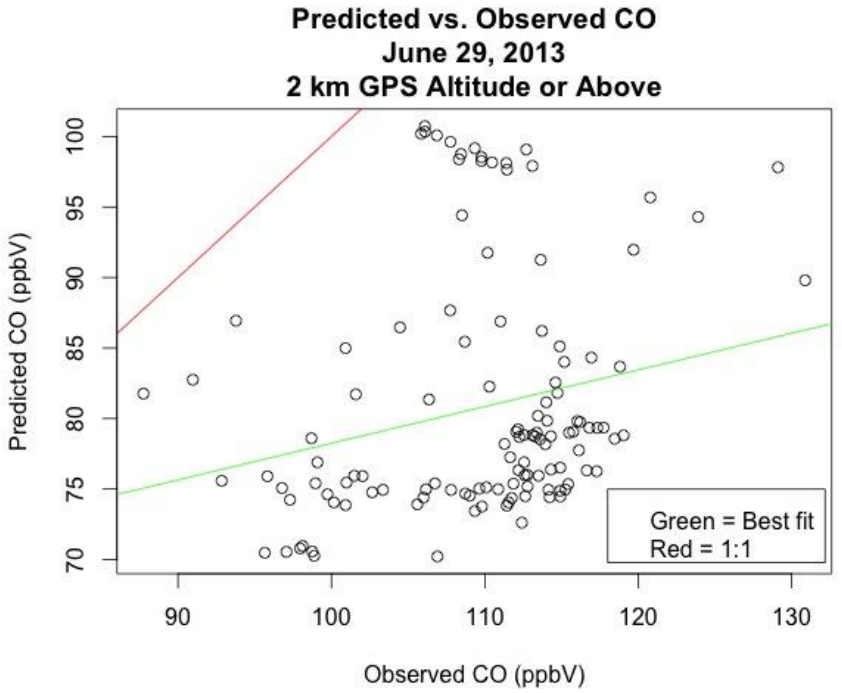
6/29/2013 SENEX Flight Path



- Passed over Birmingham, several paper mills

CO Evaluation 6/29



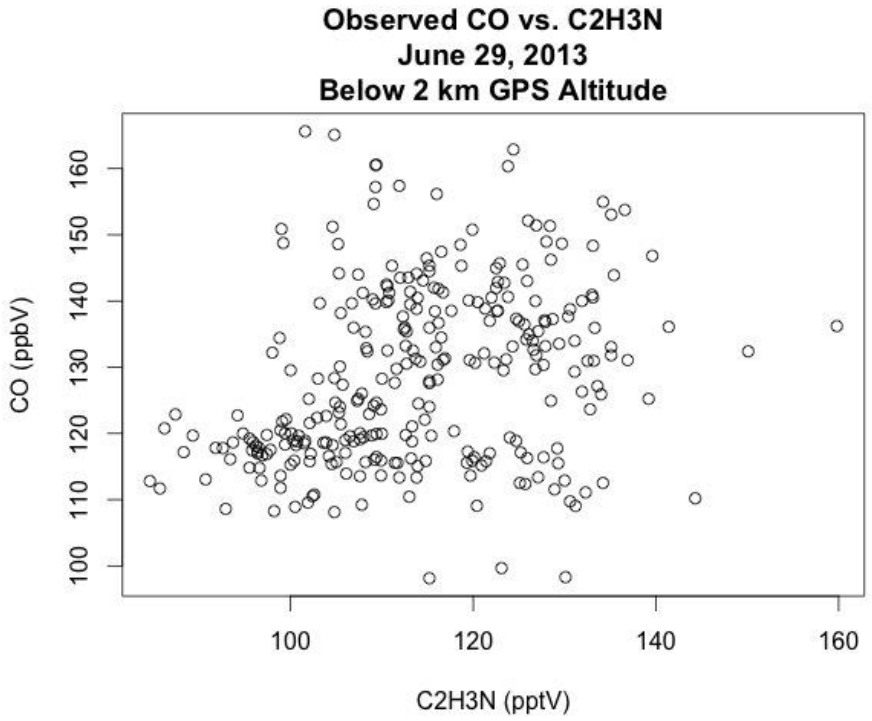


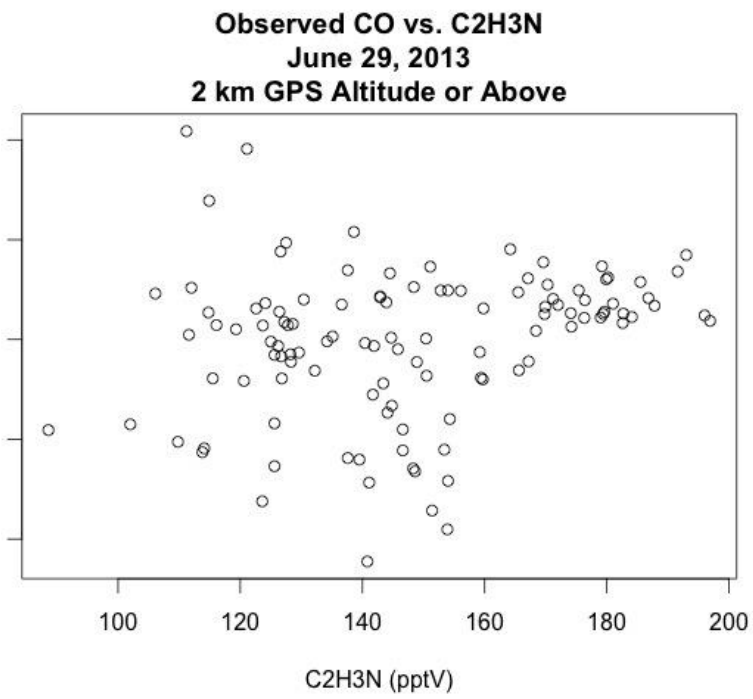
Mean bias = -34.72 ppbV
Mean error = 34.72 ppbV
N = 310

Mean bias = -28.56 ppbV
Mean error = 28.56 ppbV
N = 121

For both the upper and lower troposphere, CMAQ underestimated every data point, and the negative bias is large.

CO-C2H3N Correlation 6/29



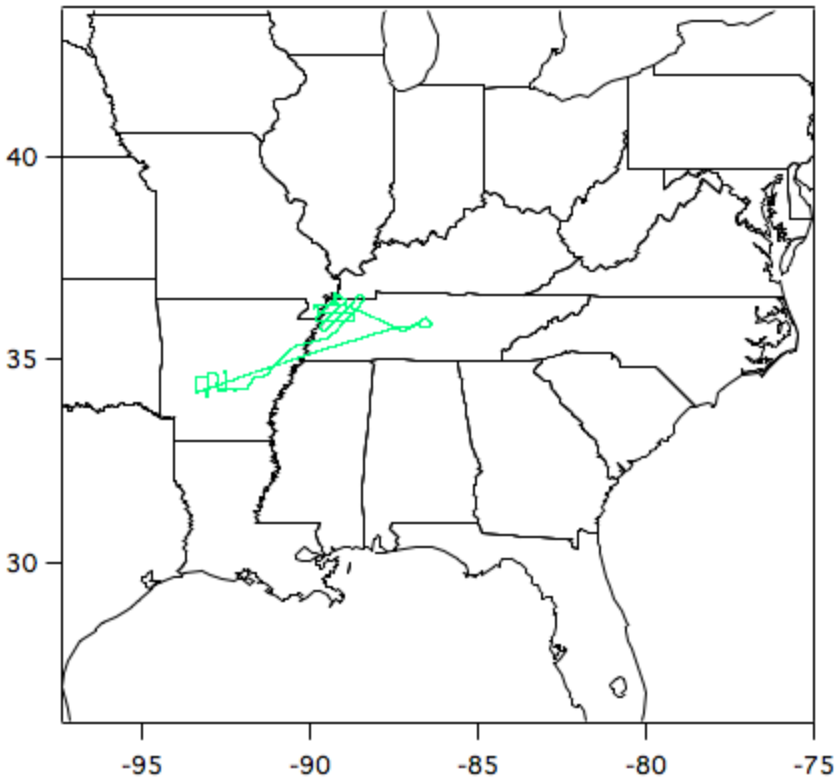


Correlation = 0.303

Correlation = 0.208

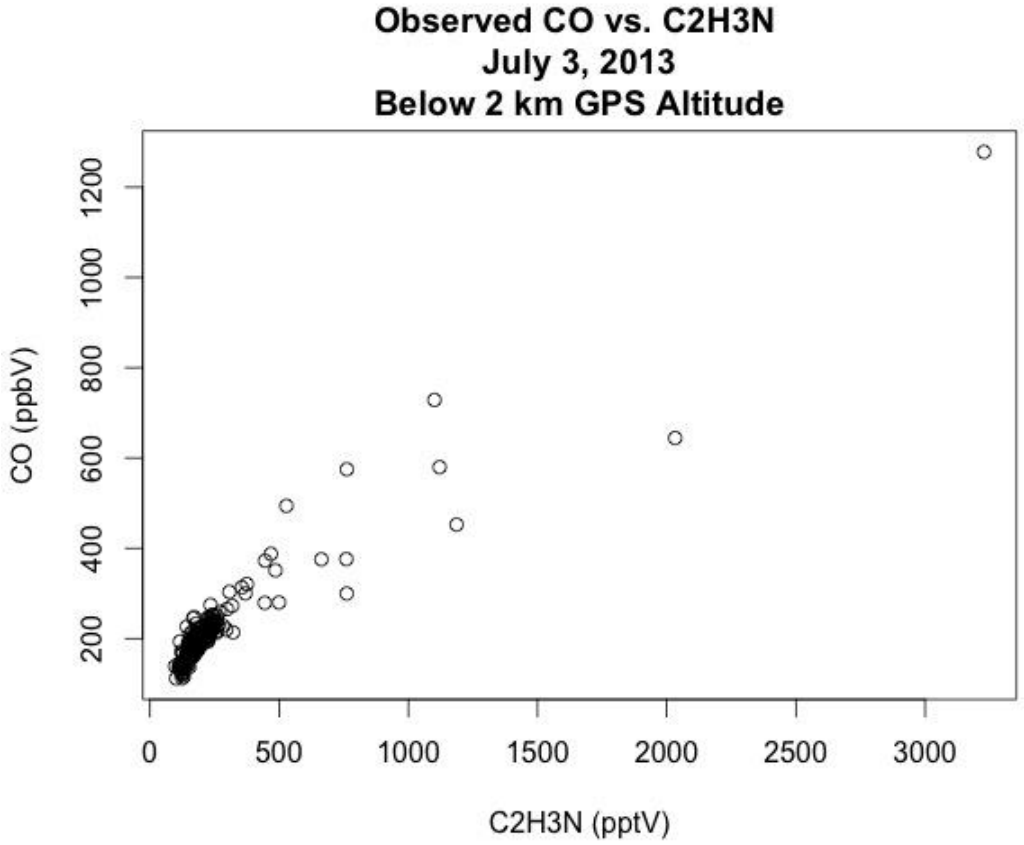
The correlation is low in both the upper and lower troposphere.

7/3/2013 SENEX Flight Path



- Passed over power plants and through power plant plumes

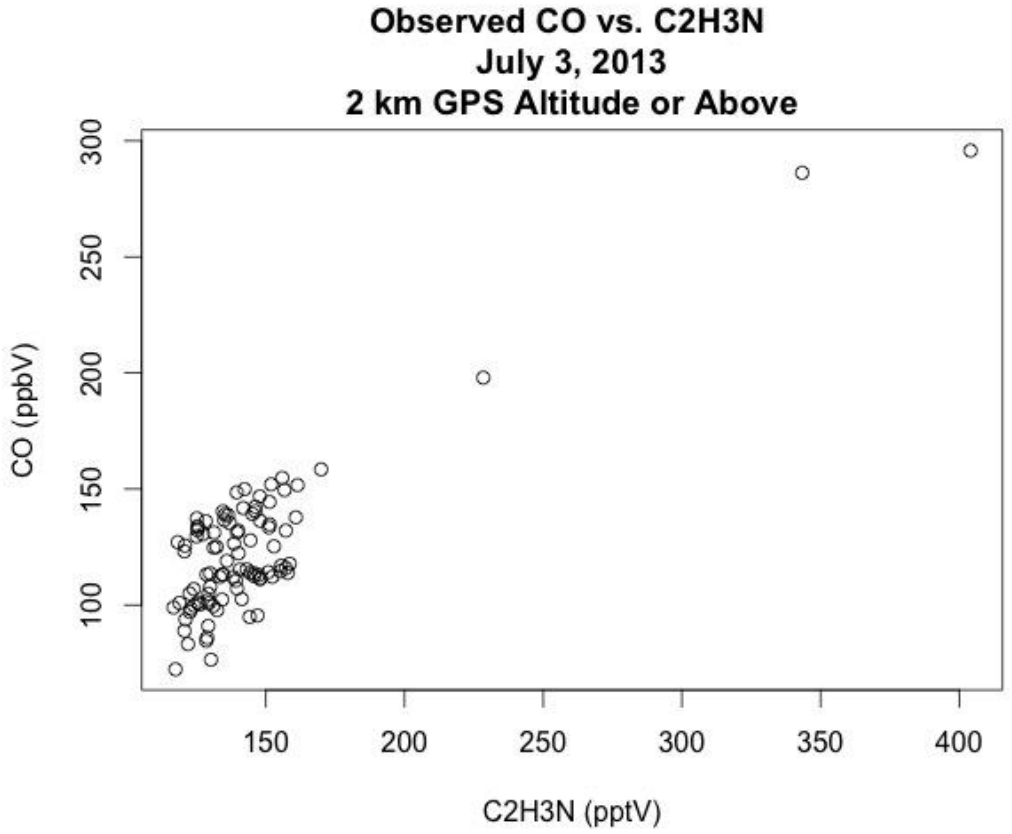
CO-C2H3N Low Altitude Correlation 7/3



Correlation = 0.935

The correlation is very high; this is the only date for which CO and C2H3N were more highly correlated in the lower troposphere than in the upper troposphere.

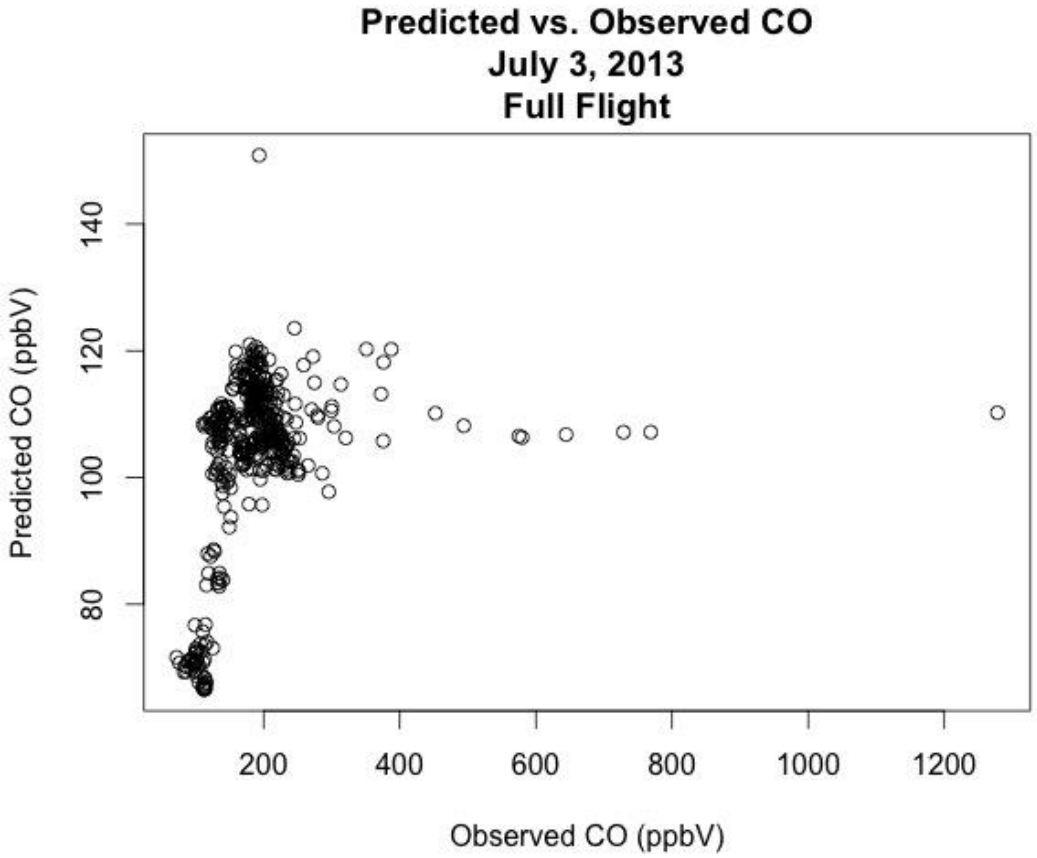
CO-C2H3N High Altitude Correlation 7/3



Correlation = 0.853

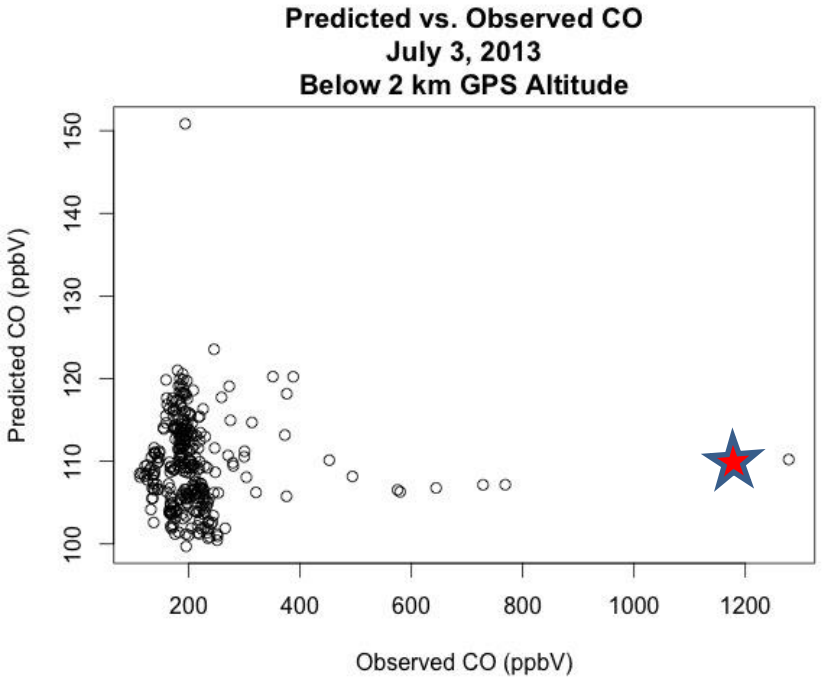
Very high correlation in the upper troposphere as well.

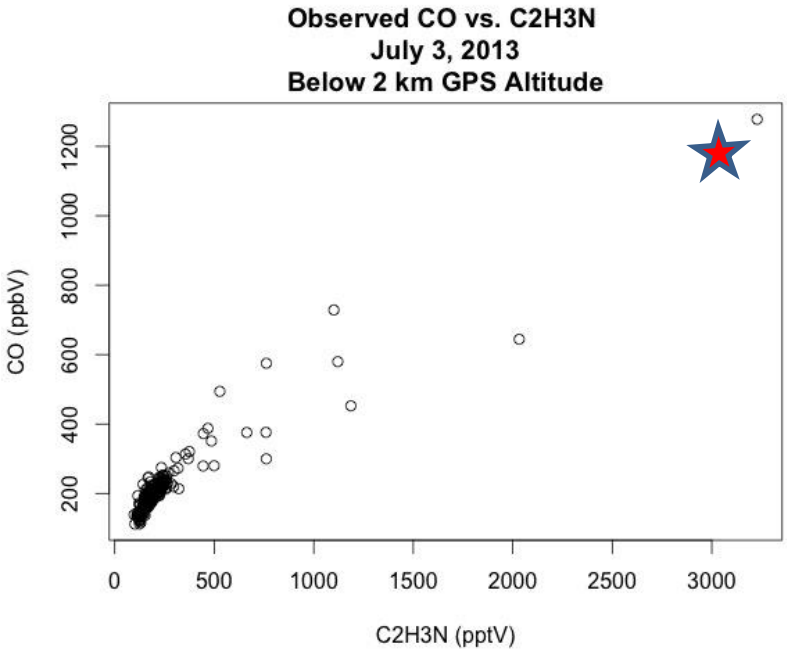
CO Evaluation 7/3



High observational values do not have correspondingly increased model values.

Plume 7/3





Mean bias = -98.63
Mean error = 98.63

These very high values that are not accounted for in the model are co-located with high concentrations of C2H3N, indicating a possible biomass burning plume.

Conclusion

- CMAQ tended to underpredict aloft CO both in the lower and upper troposphere for several days in July 2013
- Underpredictions tended to be more significant for higher observed values
- SENEX seems to have picked up a biomass burning plume during a power plant flight
- CMAQ did not catch this plume (perhaps an oversight in the HMS/BLUE SYS), resulting in extremely large underpredictions for this day

Acknowledgements

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- SENEX VOC PIs: Martin Graus , Carsten Warneke (NOAA/ESRL)